Pre AP S'mores Lab; Limiting Reagents

Purpose: To investigate limiting reagent reaction and utilize knowledge of wet lab chemistry to synthesize a delicious treat.

Introduction: It is obvious to the most casual observer that making the exquisite delight, La s'more, is not child's play. In fact, it is a study of quantitative relationships involving stoichiometry and should only be undertaken by persons of sufficient training.

Pre-lab Questions:

1. What are the main components of a written chemical equation (reaction)?

2. Define the terms limiting and reagent mean. Together they (limiting-reagent) means (in your own words and textbook definition)?

3. How is theoretical yield different from actual yield?

4. How do you think they, theoretical and actual yields, are both helpful in working with chemical reactions?

5. What is percent yield? (include a formula)

6. Use the following recipe to perform a synthesis reaction using your ingredients.

   Recipe for 1 S'more (Sm)
   2 graham cracker halves (chemical symbol Gr)
   1 chocolate bar (chemical symbol Ch)
   1 marshmallow (chemical symbol M)

7. Write a balanced equation for your reaction using the chemical symbols given. Remember that the coefficients represent how many "moles" of each reactant and product you have. This balanced equation (recipe) will be used to answer the following questions (8-12

   _____ + _____ + _____ → _____

8. If a student had 7moles of chocolate of bars how many moles of marshmallows would, been need for a complete reaction?

9. If Jenny was tasked with bringing graham cracker to a fireside chat to make S'mores. She only brought 24 graham crackers, what is the theoretical yield of S'mores that can be made based on the graham crackers she provided? **Use Stiochiometry!**

10. If Jenny's friend Chris brought 10chocolet bars, what is the theoretical yield of S'mores that could be made? **Use Stiochiometry!**
11. If Jenny and Chris's teacher provided excess marshmallows, what ***limits*** the number of S'mores that can be made? Provide proof.

12. Using the same techniques (stoichiometry) you did for determining questions number 9-11, what limits the production of lead (II) iodide in the reaction below when 3mole of lead (II) nitrate is reacted with 3moles of potassium iodide?

$$Pb(NO_3)_2(aq) + KI(aq) \rightarrow PbI_2(s) + KNO_3(aq)$$

a) What is the limiting reagent?
b) What is the non-limiting reagent or excess reagent?

Advanced Lab Procedures:

You can use a paper towel as a clean surface for your ingredients.

Step 1) Break your graham cracker into 2 pieces and a) break your chocolate into 4 pieces if using chcolet from a full size bar, if given a single unit do not break apart.
Put your chocolate onto 1 of your graham crackers.

Step 2) Roast your marshmallow over the Bunsen burner with the wood splint – **DO NOT Let Marshmallow Catch On Fire!**

Step 3) Quickly place the marshmallow onto the chocolate pieces and cover it with your second Graham cracker. Wait for it to cool and enjoy the sweet taste of success in chemistry!

Data: draw AND describe the reactants, products, and reaction mechanism

Analysis/ Post Lab:

For questions 1-4 use prelab question 7

1. Given 18 squares of Chocolate, how many S'mores can you make if the other ingredients are in excess?

2. If you wished to make 3.5 S'mores, how many Graham Cracker Halves would be needed?

3. Given 7 Graham cracker halves, 2 marshmallows and 20 squares of chocolate:
   a. What is the limiting ingredient?
   b. What is the theoretical yield of S'mores?

4. While doing the experiment described in question 3 above some sugar-starved low life steals some of your ingredients and you are only able to make 2 S'mores. What is your percent yield?

For question 5-7 use prelab question 12.

5. What is the theoretical yield of lead (II) iodide in question 12?

6. How many moles the non-limiting reagent are used?

7. How many moles of the non-limiting reagent are remaining after the reaction?

8. At high temperatures, sulfur combines with iron to form the brown-black iron (II) sulfide:

$$Fe\ (s) + S\ (l) \rightarrow FeS\ (s)$$

In one experiment, 7.62 g of Fe (MM 56g/mol) are allowed to react with 8.67 g of S (MM 32g/mol).

a. What is the limiting reagent, and what is the reactant in excess?
b. Calculate the mass of FeS (MM 88g/mol) formed.

9. Arcylonitrile, C_3H_3N (MM 53 g/mol), is the starting material for the production of a kind of synthetic fiber acrylics) and can be made from propylene, C_3H_6(MM42g/mol) by reaction with nitric oxide, NO (30g/mol), as follows:

$$4\ C_3H_6\ (g) + 6\ NO\ (g) \rightarrow 4\ C_3H_3N\ (s) + 6\ H_2O\ (l) + N_2\ (g)$$

What mass of C_3H_3N can be made when 21.6 g of C_3H_6 reacts with 21.6 g of nitric oxide?

10. Calculate the percent yield for the reaction: $P_4\ (s) + 6\ Cl_2\ (g) \rightarrow 4\ PCl_3\ (l)$ if 75.0g of phosphorus reacts with excess chlorine gas to produce 111.0 g of phosphorus trichloride (138 g/mol).

11. Formic acid, $HCHO_2$ (MM 46g/mol) burns in oxygen (32g/mol) to form carbon dioxide (44g/mol) and water as follows:

$$HCHO_2\ (aq) + O_2\ (g) \rightarrow 2\ CO_2\ (g) + 2\ H_2O\ (l).$$

If a 3.15-g sample of formic acid was burned in 2.85g of oxygen, what mass of carbon dioxide would be produced?

12. Zinc metal reacts with hydrochloric acid to produce zinc chloride and hydrogen gas.
    a. Balance the following reaction: $Zn\ (s) + HCl\ (aq) \rightarrow ZnCl_2\ (aq) + H_2\ (g)$

    b. A 3.50-g sample of zinc metal is allowed to react with 2.50 g of hydrochloric acid. Complete the following table:

Reactants/products	Zn (grams)	HCl (grams)	$ZnCl_2$ (grams)	H_2 (L)
Before reaction				
After reaction	1.26 g			

13. Consider the reaction: $MnO_2 + 4\ HCl \rightarrow MnCl_2 + Cl_2 + 2\ H_2O$
    If 0.45 mols of MnO_2 (MM 87 g/mol) can react with 48.2 g of HCl (36g/mol), how many grams of Cl_2 (70g/mol)could be produced?

14. One of the components of the fuel mixture on the Apollo lunar module involved a reaction with hydrazine, N_2H_4 (MM 32 g/mol), and dinitrogen tetraoxide, N_2O_4 (MM 92g/mol) If the balanced equation for this reaction is

$$2\ N_2H_4\ (l) + N_2O_4\ (g) \rightarrow 3\ N_2\ (g) + 4\ H_2O\ (g),$$

    a. How many moles of N_2 gas would result from the reaction of 1500 **kg** of hydrazine and 1000 **kg** of N_2O_4?

    b. What volume of N_2 gas (measured at STP) would result from the reaction in a? (use 22.4 L/mol to convert to volume)

    c. If only 6.84×10^5L of N_2 was produced, what is the percent yeild?

15. Calculate the percent yield for an experiment in which 5.50 g of $SOCl_2$ (MM 118 g/mol) was obtained in a reaction of 5.80 g of SO_2 (MM 64 g/mol) with excess PCl_5. Use the following equation:

$$SO_2\ (l) + PCl_5\ (l) \rightarrow SOCl_2\ (l) + POCl_3\ (l).$$

16. Chlorine gas reacts with silica, SiO_2 (MM 60g/mol), and carbon to give silicon tetrachloride (MM 168 g/mol) and carbon monoxide.

    a. Balance the following equation: $Cl_2(g) + SiO_2(s) + C\ (s) \rightarrow SiCl_4(l) + CO(g)$

    b. How much CO gas can be produced from 15.0 g of silica? (22.4L/mol)

17. When $Fe(OH)_2$ (MM 90 g/mol) is mixed with H_3PO_4 (MM 98g/mol), $Fe_3(PO_4)_2$ (MM 358g/mol) precipitate results.

    a. Balance the following equation:

$$Fe(OH)_2\ (aq) + H_3PO_4\ (aq) \rightarrow Fe_3(PO_4)_2\ (s) + H_2O\ (l)$$

    b. If 3.20 g of $Fe(OH)_2$ is treated with 2.50 g of phosphoric acid, what is the limiting reagent and what is the reactant in excess?

    c. How many grams of $Fe_3(PO_4)_2$ precipitate can be formed?

    d. If 3.99 g of $Fe_3(PO_4)_2$ is actually obtained, what is the percent yield?

Some Answers:

8. a. Fe = LR, S=NLR, b. 12.2gFeS 9. 25.5 g C_3H_3N 10. 33.3%

12. $Zn\ (s) + HCl\ (aq) \rightarrow ZnCl_2\ (aq) + H_2\ (g)$

Reactants/product	Zn (grams)	HCl (grams)	$ZnCl_2$ (grams)	H_2 (L)
Before reaction	**3.50**	**2.50**	**0**	**0**
After reaction	1.26 g	**1.26**	**4.67**	**0.768**

16.a $2\ Cl_2\ (g) + SiO_2\ (s) + 2\ C\ (s)$ b. 14.0 g CO gas

17. a. $3Fe(OH)_2\ (aq) + 2H_3PO_4\ (aq) \rightarrow Fe_3(PO_4)_2\ (s) + 6H_2O\ (l)$ b. $Fe(OH)_2$=LR, H_3PO_4 NLR

c. 4.24 g $Fe_3(PO_4)_2$ (s) d. 94.0%